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ABSTRACT

The effectiveness of learning paired associates from a computer-based drill strategy known as the progressive state drill was compared in this study with the effectiveness of having students use their own strategies with flashcards. Characteristics of the progressive state drill which make it a potentially effective drill and practice strategy for learning paired associates include: (1) the use of a small working pool of items; (2) increasing ratio review; (3) dynamic adjustment of the drill based on student performance; and (4) recordkeeping from session to session. The 96 high school sophomores who acted as subjects were placed into matched pairs on the basis of a pretest which measured their ability to remember word-number pairs, and one member of each pair was randomly assigned to the flashcard or microcomputer group. The treatment consisted of three 20-minute sessions, i.e., one session each day for three consecutive days. Although the results failed to show any superiority on a posttest achievement measure for the progressive state drill over the flashcard approach, the microcomputer group demonstrated a significantly more positive attitude toward the instruction. A discussion of the implications of these findings for design and use of microcomputer drills such as the progressive state paradigm conclude the paper. Statistical analyses and a list of 26 references are appended. (MES)

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A Comparison of a Microcomputer Progressive State Drill and Flashcards for Learning Paired Associates

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Running head: PROGRESSIVE DRILL

Abstract

Among the uses of the computer in education, drill and practice ranks as one of the most popular. Yet, in spite of the pervasiveness of these drills, relatively few studies have been done to compare the effectiveness of various computer-based drill strategies with each other or with other methods of practice. This study compares the effectiveness of learning paired associates from a computer-based drill strategy known as the progressive state drill with the effectiveness of having students use their own strategies with flashcards. The progressive state drill is a fairly sophisticated drill structure which includes several characteristics which make it appear to be a potentially effective drill and practice strategy for learning paired associates. Some of these characteristics include: use of a small working pool of items, increasing ratio review, dynamic adjustment of the drill based on student performance, and record keeping from session to session. Results, however, failed to show any superiority on a posttest achievement measure for the progressive state drill over the flashcard approach. There was a difference in attitude of the two groups toward the instruction, with the microcomputer group demonstrating a significantly more positive attitude. Implications for design and use of microcomputer drills such as the progressive state paradigm are discussed.

A Comparison of a Microcomputer Progressive State Drill and Flashcards for Learning Paired Associates

Computer drills are becoming more and more popular. Various computer-based drill and practice strategies have been described in the literature (Allesi and Trollip, 1985; Atkinson, 1974; Merrill & Salisbury, 1984; Salisbury, in press; Seigal & Misselt, 1984). Usually these computer-based drill strategies are compared with simple flashcard strategies to show their superiority. However, few studies have been done to compare these various strategies with one another or to compare the effect of learning from a particular computer-based drill strategy with the effect of having students use their own strategies with flashcards.

The purpose of this study was to compare the effectiveness of a computer-based drill strategy known as the progressive state strategy with the effect of having students learn the same material using their own strategy with flashcards. The study examined the effect of the progressive state drill on student post-test performance and attitude toward the instruction. The post-test performance and attitude of a group of subjects who tried to learn the content by means of the progressive state drill were compared against the same measures of a group of subjects who tried to learn the content by using their own strategy with flashcards.

Description of the Progressive State Drill Strategy

The progressive state drill strategy includes several characteristics which make it potentially effective. Some of these are: (a) use of a small working pool of items, (b) an increasing ratio review schedule, (c) dynamic adjustment of the drill based on student performance, and (d) record keeping from session to session. The term progressive state is used to describe the drill since items are presented to the learner in a progressive sequence passing from one presentation state to another based on performance criteria for each state. Box 1 shows a flowchart for a progressive state drill. In this drill items are presented in six different states. These are:

1. Pretest state - used to determine if the learner already knows the item

2. Rehearsal state - presents item and response simultaneously on the screen for a brief moment to allow learner to associate them together. The learner is then asked to type in the correct response.

3. Drill state - presents the item and prompts learner for correct response

4. First Review state - identical to how item was presented in drill state

5. Second Review state - same as first review state

6. Third Review state - same as first review state

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Insert Box 1 about here

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Each item in the drill has a state number associated with it. This state number indicates the current state of the item and determines the presentation state in which the item will be presented. When the learner begins a practice session any items left in the learner's working pool from the last session are transferred from the disk to the current working pool (Step 1). Review dates and state numbers corresponding to each of the items are also transferred from the disk. If the working pool is not full, then additional items are selected from the review pool if there are any review items which have review dates less than or equal to today's date (Steps 3 and 4); otherwise additional items are selected from the new item pool (Step 5). After the working pool is shuffled (Step 6), the first item is selected and its state noted (Steps 7 and 8). If the item has just entered the drill as a new item, it will be presented as a pretest item (State 1). If the learner responds correctly to the item, it will be deleted from the system. Otherwise, its state will be updated to State 2. The value of the item counter (N) is then incremented, and the second item from the working pool is selected (Step 7 again). This item is presented in accordance with its specified state. After all the items in the current working pool have been presented once (N 7), the working pool is replenished and shuffled (Steps 1 - 6), and the item counter (N) is set back to 1 (Step 7). This process is repeated until the learner terminates the practice session. Note that after an item is presented in State 3 (drill), it is removed from the working pool and transferred into the review pool. The review pool is divided into three states to provide increasing ratio review.

Simply stated, increasing ratio review means that new and

review items will be intermixed throughout the drill with the ratio of review to new items increasing as the drill progresses. When the learner first begins the drill, all items will be new items. As the learner masters items, these become review items and are reintroduced systematically into the drill based on time elapsed since the learner was last presented that item. Toward the end of the drill most of the items will be review items with only a few new items being introduced.

Drills which are structured in this way are very useful for the purpose of skill maintenance in addition to initial learning. Learners can work on the drill initially to master the content and then they can continue to use the drill from time to time to review and re-check mastery. Typically, once a person has attained a high level of accuracy and precision on a skill, it can be maintained at that level over a long period of time with only a small amount of practice at regular intervals.

In order to construct a drill with increasing ratio review it is necessary that each item in the review pool have a review date associated with it. This review date indicates when the item is next to be reviewed. When the learner begins a practice session, any items left in that learner's working pool from the last session are transferred from the disk to the current working pool. The working pool is shuffled and the items in the working pool are presented to the learner. If the learner gives a correct response to an item the item goes into the review pool. If an incorrect response is given the item remains in the working pool. Steps 3-5 of Box 1 show how the working pool is replenished. The procedure first checks to see if there are any items in the review pool which are ready for review (Steps 3 and 4). An item is ready for review when its review date is equal to or less than the current date. Otherwise, the replacement item is a new item from the item pool (Step 5).

Hypothesis

The presence of the desirable instructional characteristics of the progressive state drill mentioned above (small working pool, increasing ratio review, dynamic adjustment of the drill based on student performance, and record keeping from session to session) give reason to believe that students using this drill might perform better on a post-test than students using their own strategies with flashcards. However, there is also a theoretical basis to suggest the flashcard group might learn better than students using the progressive state drill. The basis for this arises from cognitive learning research which suggests that students learn verbal information by paying attention to the "meaning" of the material and organizing structural representations of the material in their minds (Anderson, 1980; Salisbury, 1984; Salisbury, Richards, & Klein, 1985). To promote the formation of these structural representations, students

should be able to identify important relationships, sequences, or groups present in the material. The progressive state drill paradigm, like most other computer-based drill paradigms, presents only one item at a time to the student, making it difficult for the student to form his or her own groupings or sequences. In contrast, with flashcards, students can lay out several flashcards on the table to form groups and they can group them any way they wish. Pilot research done by the experimenters suggested that with learners who have fairly well developed study strategies, the flexibility of flashcards provides an advantage over a structured computer-based drill such as the progressive state drill. Since a theoretical base existed to suggest the possible superiority of either group, a two-tailed statistical test was chosen. The hypothesis (stated in the null form) was that there was no statistically significant difference in learning between the PSD group and the flashcard group. A second null hypothesis was that there was no statistically significant difference in attitude toward the instruction between the two groups.

Design

This study utilized a statistical methodology known as sequential analysis (King & Roblyer, 1984; Weed & Bradley, 1971). In sequential analysis the sample size for an experiment is not specified in the research design. Instead, certain decisions are made by the investigator prior to the collection of data. The characteristics of these data as they are obtained and analyzed determine the point at which the number of observations is sufficient for the experiment to be terminated.

In a sequential analysis study, a set of observations is obtained and the data from this first set of observations is analyzed. Based on the results of this and any prior observations, one of three decisions is made: (a) accept the null hypotheses, (b) accept an alternative hypothesis, (c) or obtain more observations. The principal advantage of sequential analysis over designs which specify a fixed sample size is its greater efficiency. Since, in sequential analysis, data are analyzed as they are obtained, it is often the case that decisions can be reached with fifty percent or fewer observations than would be possible with other types of research designs.

Method

The task consisted of learning 100 word-number pairs which were unfamiliar to the subjects. Examples of word-number pairs are 1 - HAT, 10 - TOES, 30 - HEAD. The complete set of 100 items is shown in Figure 1. Subjects were high school sophomores from the Developmental

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Insert Figure 1 about here

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Research School at Florida State University. Ninety-six potential subjects were pretested using the Object-Number Test developed by Educational Testing Service (1963) as a measure of their ability to remember word-number pairs of the type that were to be employed in the study. Subjects were placed into matched-pairs based on their pretest scores and one member of each pair was randomly assigned to either the group using flashcards or to the microcomputer group.

The treatment consisted of three twenty minute sessions, one session each day for three consecutive days. Subjects in the flashcard group were allowed to use the flashcards in any manner they wished but were required to work alone. Subjects in the microcomputer group used the progressive state drill to learn the same material. Due to space limitations, the study had to be carried out over a period of several weeks, with an equal number of subjects assigned to the two treatments each week. This process was continued until, under the rules of sequential analysis, enough observations had been obtained to accept or reject the two null hypotheses.

Results

Post-test Data. As mentioned in the design section, in a sequential analysis, after the data from one set of observations have been analyzed, one of three decisions is made: (a) accept the null hypothesis, (b) accept the alternative hypothesis, (c) or obtain more observations. The point at which one arrives at one of these three alternatives will be influenced by the design parameters specified in advanced by the researchers. For this study, we set alpha at .05, beta at .20, and specified an effect size (ES) of three-fourths of a standard deviation, meaning that we were interested in detecting any difference between groups that was larger than 3/4 S.D. (or about 9 items on the post-test). Two groups each containing nine pairs of subjects were tested before the decision was made to stop. Table 1 shows the signed differences between the pairs. In group one, only eight differences are shown because the scores of one pair were tied and no information concerning the relative effectiveness of the two treatments could be obtained from them (see Wilcox on Signed Rank Test, 1945). A negative sign indicates that the score of a flashcard subject was greater than that of his/her paired PSD counterpart.

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Insert Table 1 about here

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Since the test statistic indicated that the difference between the two groups was not significant at the parameter levels specified, the decision was to accept the null hypothesis and to conclude that there was no significant difference in the performance of the progressive state drill group and the flashcard group on the posttest. Because the effect size of interest (3/4 S.D.) was chosen in advance (the effect size being the minimal amount of effect which would be of practical importance to detect) this result can also be interpreted as indicating that there is no difference that is of practical importance between the two groups.

Attitude Data. Table 2 shows the signed differences between pairs on the attitude measure. This time the test statistic indicated that the difference between the groups was significant and the decision was made to accept the alternative

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Insert Table 2 about here

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hypothesis and conclude that there was a significant difference in attitude between the progressive state drill group and the flashcard group. The raw data on the attitude measure indicated the difference was in the direction of the progressive state drill group with that group exhibiting a more positive attitude toward the instruction. Again, because the effect size of interest was specified in advance, this result can be interpreted to be a significant difference in statistical terms as well as in practical terms. Means and standard deviations for the progressive state drill group and for the flashcard group are presented in the traditional fashion in Table 3.

Summary and Discussion

The research question explored by this study was whether there would be a significant difference in post-test performance or in attitude toward the instruction between a group of subjects that learned paired-associations using a progressive state drill on a microcomputer and a group which used their own strategy with flashcard. The results of this study show no significant difference in post-test performance between subjects using flashcards and those using the progressive state drill. However, there was a difference in attitude of the two groups toward the

instruction with the microcomputer group demonstrating a significantly more positive attitude. Some conclusions and implications for the design of practice drills which can be drawn from the study are given below.

First, it might be concluded that students in this age group have fairly sophisticated strategies for learning from flashcards. The subjects in this study tended to use fairly sophisticated practice and review strategies with the flashcards. For example, most subjects separated the 100 flashcards into separate piles for learning and most reviewed flashcards which they had learned in a fairly systematic manner.

Second, even though the subjects in the flashcard group exhibited a less positive attitude towards the instruction, they learned as many word-number pairs as the subjects in the PSD group. This may add to the body of research which suggests that students do not learn the most from the type of instruction they claim to like the best (Clark, 1982; Clark, 1983).

This study also suggests that designers of computer-based drills more seriously consider the implications of cognitive research on learning verbal information. There is a great deal of literature to suggest that the more meaningful the to be learned material is, the easier it will be learned (Anderson, 1976; Wanner, 1968; Pompi and Lachman, 1967). Because students can remember meaningful information better than meaningless information, instruction should seek to make material as meaningful as possible. This can be done by providing images which relate things together or by emphasizing networks or relationships inherent in the content (Bower, 1970b; Dansereau, 1978; Weinstein, 1978, 1982; Vaughn, 1981) and also through the use of acronyms, mediators, and mnemonics. Other memory techniques such as link and loci (associating material to be learned with spatially organized objects and places) have been shown to help impose some arbitrary meaning on otherwise meaningless material (Bower, 1970a; Bower, 1970c; Gilbert, 1978; Higbee, 1977).

Computer drills which present single items to the learner one at a time are generally intended, not for initial learning, but for practice of material to which the student has already been exposed. Computer drills are generally intended to be used in conjunction with some other means of instruction (computer tutorial, narrative presentation, textbook, etc.) which presents the material initially to the learner. The initial learning of the material should allow the student to utilize some of the techniques mentioned in the previous paragraph. Perhaps flashcards provided the subjects in this study more opportunity to form groups and study relationships among the items, than did the PSD.

The result showing that the subjects using the PSD exhibited a more positive attitude toward the instruction is of practical importance. What this means is that even though students might learn as well using flashcards as they would if they used the PSD on a microcomputer, it is unlikely that they would be motivated to stick with the task. The computer drill is significantly more motivating and engaging. In this study, the flashcard group functioned in a supervised, structured environment and this undoubtedly contributed to the on-task behavior on these subjects.

Finally, some questions can be raised concerning the generalizability results of this study. Since the PSD is designed to be used over a long period of time, it is possible that the design characteristics of the PSD (increasing ratio review, keeping track of working pool from session to session) did not have time to demonstrate their effect during the duration of the experiment. Different results would perhaps be obtained were the subjects to use the PSD for a longer period of time.

It should also be pointed out that the results of this study should not be generalized to different age groups. Younger students undoubtedly would use less sophisticated strategies with flashcards and a comparison between them and the PSD would possibly render very different results.

We would like to add a note of caution. This study should not be viewed as a member of that genre of studies known as "media comparison" studies. The study is not a comparison of microcomputers and flashcards. It does not seek to determine which medium is more effective for learning in general, or for learning paired-associates, specifically. Rather, it is a comparison of one particular drill strategy (the PSD) with students' own flashcard strategies. Different results might be obtained for different strategy comparisons.

Although the results of the study showed "no significant difference" in post-test performance between the two groups, we feel that this study provides a valuable contribution to the literature on computer-based instruction in that it is one of the experimental studies in this area in which the researchers specified in advance the alpha level (of Type 1 error), the effect size of interest, and the statistical power (1-beta) desired to detect a difference if it did exist. Only when these levels are specified in advance can a sample size be assured that is adequate to detect a difference between the groups.

Also, the methodology known as sequential analysis is a valuable alternative methodology for researchers in the area of computer-based instruction. Sequential analysis allows the researcher to avoid having to predetermine the sample size. In most cases, a decision can be reached with fewer observations

than would be possible with other types of research designs. Sequential analysis also requires the investigator to make certain decisions prior to conducting the experiment regarding the conditions under which the null hypothesis can reasonably be regarded as true. Recent secondary analyses of the statistical power of research studies in the behavioral sciences (Daly & Hexamer, 1983) indicate that in the great majority of studies power is quite low, (i.e. type two error rates are large). When using sequential analysis, the researcher is required to consider power a priori thus assuring that the sample size is large enough to detect a difference between the groups.

Computer drill and practice programs are widely viewed as potential instructional tools for teaching. More studies should be done to compare various computer-based drill and practice paradigms with one another and with non-computer-based strategies.

Author Note

The specific sequential analytic technique used in this study was the Sequential One-Sample (Paired Samples) Configural Signed Rank Test (CSRT) originated by Weed and Bradley (1971). The design parameters required by this test are alpha, beta, and the effect size (ES) one wishes to be able to detect. For this experiment, these parameters were set as follows: alpha = .05, beta = .20, ES = three-fourths of a standard deviation. In this test the differences between the scores of the matched pairs in each group are compared and rank ordered in terms of their absolute magnitudes. The probability of the particular configuration of signed ranks is computed under a hypothesis of no difference, H_0, and also under an alternate hypothesis, H_1, in which a difference in favor of one group of 3/4 S.D. or more is postulated. Data are then collected until the researcher reaches the point at which H_0 or H_1 can be accepted. In the current study, a two-tailed version of the CSRT was desired so the probability ratio was modified to test the alternative hypothesis that the ES was $\pm$ 3/4 S.D.

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Table 1

Signed Achievement Differences Between Pairs of Students in the Two Groups: Posttest

Rank Ordered Differences Between Pairs		Configuration of Signed Ranks	
Group 1	Group 2	Group 1	Group 2
-21	34	-X	X
-18	28	-X	X
-13	-17	-X	-X
9	-16	X	-X
-7	16	-X	X
-6	-8	-X	-X
-5	-8	-X	-X
3	5	X	X
	-3		-X

Note 1: A negative sign indicates that the score of the flashcard subject in that pair was greater than his/her PSD counterpart. In group one, only eight differences are shown because the scores of one pair were tied and no information concerning the relative effectiveness of the two treatments could be derived from them.

Note 2: The rejection region for the test statistics is based on alpha =.05, B = .20, and ES = 3/4 S.D.

Table 2

Signed Differences Between Pairs of Students in the Two Groups: Attitude Measure

Rank Ordered Differences Between Pairs		Configuration of Signed Ranks	
Group 1	Group 2	Group 1	Group 2
45	39	X	X
44	37	X	X
30	24	X	X
29	-22	X	-X
24	19	X	X
12	-15	X	-X
-11	-14	-X	-X
9	7	X	X
5	5	X	X

Note 1: A negative sign indicates that the score of the flashcard subject in that pair was greater than his/her counterpart.

Note 2: The rejection region for the test statistics is based on alpha =.05, B = .20, and ES = 3/4 S.D.

Table 3

Means and Standard Deviations for the PSD Group and the Flashcard Group

	Posttest		Attitude	
	PSD	Flashcards	PSD	Flashcards
Mean	21.9	22.8	74.3	57.9
S.D.	11.8	14.8	9.6	16.9